SUB : WELDING TECHNOLOGY

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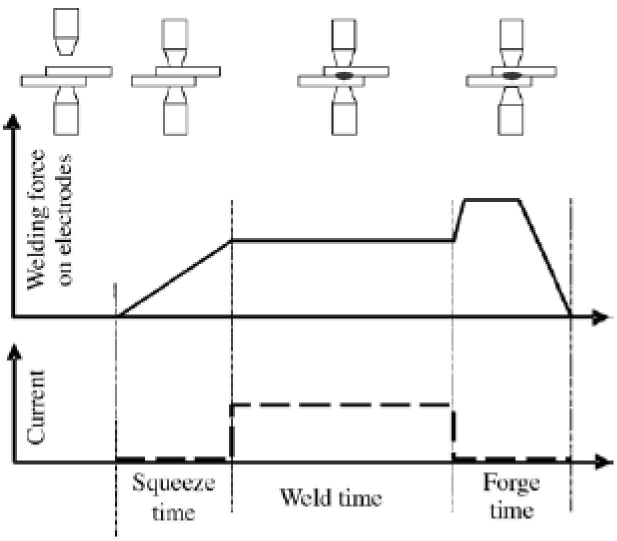
UNIT III RESISTANCE WELDING 10 hrs.

Resistance welding processes and equipment -Heat generation and its calculations -Parameters effecting heat generation -Spot welding -Seam welding -Resistance butt welding-Flash butt welding-Percussion butt welding - stud welding- Electrodes -Applications and limitations -Welding defects

RESISTANCE WELDING

The basics of resistance welding are quite simple. It is the application of heat energy and pressure to produce a weld. It is the proper association and application of the basics that are our real concern in resistance welding. Simply stated, heat energy is added to a system to raise the temperature to reach the plastic, or near molten, state of the materials to be welded. The changes of state of material, due to these applications of heat energy, can be explained by using water as an analogy to steel. By definition the basic functions of resistance welding are pressure, current and time. Steel, as it is seen at most times, is in the solid state. The solid state of water is ice. As heat energy is added to ice, the ice melts and becomes liquid water. As heat energy is added to the water it becomes a gas, or steam as we recognize it. The same changes are true with a piece of steel. Recognize that both the amount of heat energy and temperatures to reach these changes of state are much greater for steel than water. Water melts at approximately 32F; steel at approximately 2800F. Water boils, becomes a gas, at 212F; steel at approximately 5000F. During each change of state, heat energy must be added to cause the change of state, although during this time there is no change in temperature. Figure 2. For zinc coated steel (galvanized steel), see Figure 27 on Page 28. The heat energy needed to change a solid to a liquid is called the Latent Heat of Fusion. The heat energy needed to change a liquid to a gas is the Latent Heat of Vaporization. Resistance welding deals with the heat energy necessary to raise the temperature of the solid to the point of the Latent Heat of Fusion and then terminating the application of heat energy before the solid is converted completely to a liquid. If the steel is converted to a liquid metal, expulsion will result. This is represented by "sparks" at the area of heat energy application. The Latent Heat of Fusion is essentially the end of the "plastic" range of the metal. Steel has a relatively long "plastic" or transition temperature range. Aluminum and most other non-ferrous metals have a much shorter "plastic" range. This is one important reason that greater control of the resistance weld is required for most metals other than steel.

There are two basic laws of physics involved in resistance welding: OHM'S LAW, the relationship between the voltage, current and resistance in an electrical circuit. That is: E=IR. Where E is the voltage, I is the current and R is the resistance in the circuit. The R in Ohm's Law is the R in Resistance Welding. Ohm's Law is the Law that makes resistance welding work. Unfortunately, a violation of Ohm's Law is almost always the reason why resistance welding does not work at any given time. JOULE'S LAW, a unit of work energy, is the heat energy expended by an electric current of 1 ampere flowing through a 1 ohm resistance for 1 second. That is H=I2 RT, where H is the heat energy, I2 is the current squared, R is the resistance in the circuit and T is the time the current is allowed to flow. The weld control can only regulate the current (I) and the time (T). R is a variable associated with the machine set up and proper maintenance. The effects of Ohm's Law and Joule's Law on resistance welding will be covered in more detail later in the text. THE THREE IMPORTANT FACTORS IN MAKING A WELD CURRENT, PRESSURE AND TIME - (P C T) Important to the proper formation of the weld nugget between the pieces of metal being welded is the resistance of the metal, the magnitude of current, the length of time current flows, and the force squeezing the parts together. The heat energy is expressed as the square of the current times the resistance of the material times the weld time (H=I2 RT), Joule's Law. The optimum value of these parameters varies with the type of metal, the metallurgy, its thickness, and its strength. Always start with the material to be welded. This is the known factor that determines the values of pressure, current, and time required to make a good weld. As an example, for commonly used low-carbon steel, 1/16" thick, a typical value of current may be about 10,000 amps; a time of approximately 1/4 second (15 cycles, at 60 Hz); and about 600 pounds of electrode force can be used to make a good weld. Resistance welding schedules are available through the American Welding Society, Resistance Welding Manufacturing Alliance, and from most welding machine manufacturers



HOW THE ELECTRODE FORCE IS OBTAINED

Another critical factor in resistance welding is the force squeezing the metal parts together (Electrode Force). This force is necessary to assure good electrical contact between the parts being welded, and to hold the parts steady until the near molten metal forming the welded joint has time to solidify. Depending on the size and type of welding machine, various methods of developing the electrode force are used. It is most common to use compressed air in a cylinder and piston arrangement. The cylinder is rigidly attached to the welding machine frame, and the moveable piston is connected to the upper electrode. Hydraulic and mechanical systems are also available. Compressed air or hydraulic fluid introduced into the cylinder develops a force on the piston which, in turn, pushes the electrode down against the metal to be welded. Figure 5. The amount of force applied depends on the area of the piston and the pressure of the compressed air or hydraulic

Resistance welding is a group of thermo-electric processes in which coalescence is produced by the heat obtained from resistance of the work to electric current in a circuit of which the work is a part and by the application of pressure.

Said another way, pressure is applied to the two overlapping sheets being joined. Electrical current is applied causing resistive heating, which results in the melting of metal and the formation of a weld. The weld is called a weld nugget.

There are at least seven important resistance-welding processes. These are:

- flash welding
- high frequency
- percussion welding
- projection welding
- resistance seam welding
- resistance spot welding (most common process), involves the use of water cooled copper electrodes which are clamped with the sheets into place. The electrical current is then applied to the electrodes causing the weld nugget to form.
- upset welding

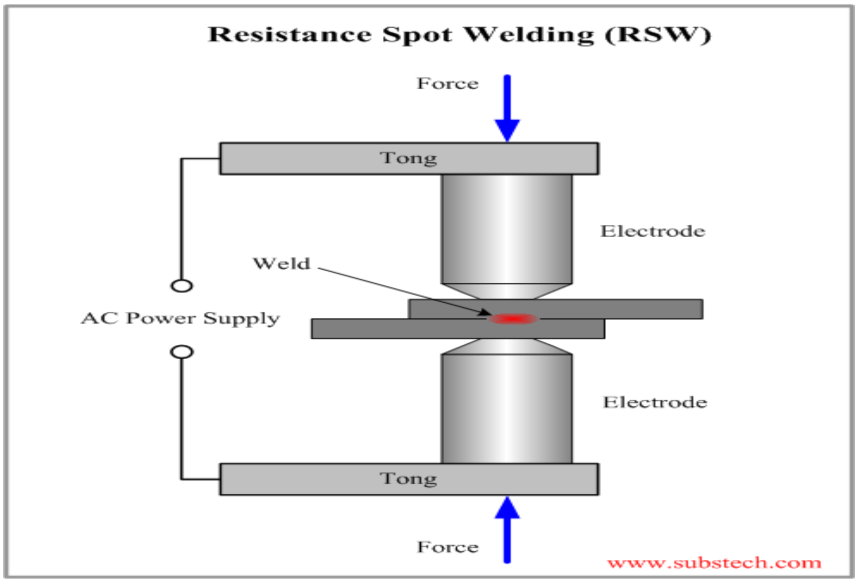
Applications:

This type of welding is used where long production runs and consistent conditions can be maintained. Welding is performed with operators who normally load and unload the welding machine and operate the switch for initiating the weld operation. The automotive industry is the major user of the resistance welding processes, followed by the appliance industry. Resistance welding is used by many industries manufacturing a variety of products made of thinner gauge metals.

This type of welding is also used in the steel industry for manufacturing pipe, tubing and smaller structural sections. It has the advantage of producing a high volume of work at high speeds and does not require filler materials. Welds are reproducible and high-quality welds are normal.

Resistance spot welding is a process in which faying surfaces are joined in one or more spots by resistance to the flow of electric current through workpieces that are held together under force by electrodes. The contacting surfaces in the region of current concentration are heated by a short-time pulse of low-voltage, high-amperage current to form a fused nugget of weld metal. When the flow of current ceases, the electrode force is maintained while the weld metal rapidly cools and solidifies. The electrodes are retracted after each weld, which usually is completed in a fraction of a second. The size and shape of the individually formed welds are limited primarily by the size and contour of the electrode faces. The weld nugget forms at the faying surfaces, as shown in Figure 1, but does not extend completely to the outer surfaces. In section, the nugget in a properly formed spot weld is round or oval in shape; in plan view, it has the same shape as the electrode face (which is usually round) and approximately the same size. Spacing between adjacent spot welds or rows of spot welds must be enough to prevent shunting or to limit it to an acceptable amount.

RESISTANCE SPOT WELDING



Spot Welding is a Resistance Welding (RW) process, in which two or more overlapped metal sheets are joined by spot welds.

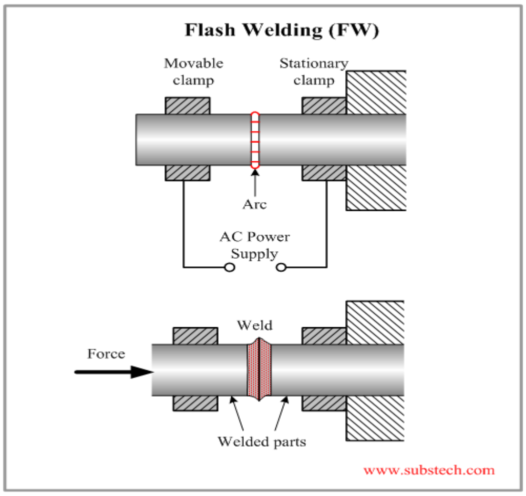
The method uses pointed copper electrodes providing passage of electric current. The electrodes also transmitt pressure required for formation of strong weld.
Diameter of the weld spot is in the range 1/8” - 1/2” (3 - 12 mm).

Spot welding is widely used in automotive industry for joining vehicle body parts.

Flash Welding

Flash Welding is a Resistance Welding (RW) process, in which ends of rods (tubes, sheets) are heated and fused by an arc struck between them and then forged (brought into a contact under a pressure) producing a weld.

The welded parts are held in electrode clamps, one of which is stationary and the second is movable.

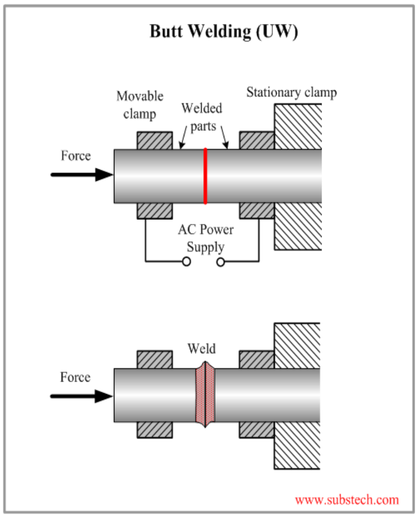


Resistance Butt Welding

Resistance Butt Welding is a Resistance Welding (RW) process, in which ends of wires or rods are held under a pressure and heated by an electric current passing through the contact area and producing a weld.

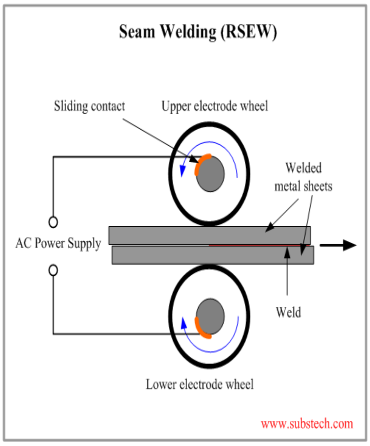
The process is similar to Flash Welding, however in Butt Welding pressure and electric current are applied simultaneously in contrast to Flash Welding where electric current is followed by forging pressure application.

Butt welding is used for welding small parts. The process is highly productive and clean. In contrast to Flash Welding, Butt Welding provides joining with no loss of the welded materials.



Seam Welding (RSEW)

Seam Welding is a Resistance Welding (RW) process of continuous joining of overlapping sheets by passing them between two rotating electrode wheels. Heat generated by the electric current flowing through the contact area and pressure provided by the wheels are sufficient to produce a leak-tight weld.



Percussion Welding:

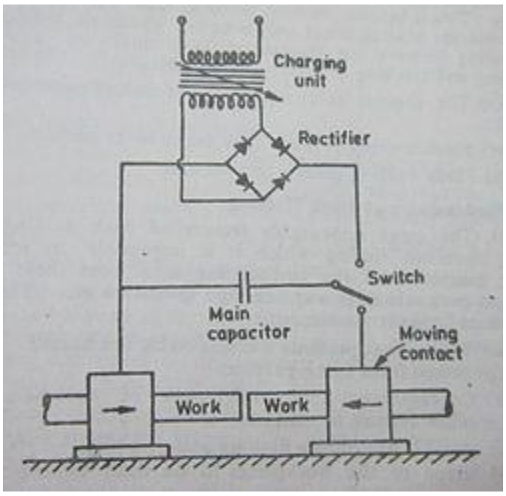
Percussive arc welding has been around for years, but it's only recently that technology capability and commercial demand have converged to expose some genuine component production advantages. Percussion welding has the best features of 19th century technology. It is a "heat it and beat it" method that can be readily automated using straight forward electromechanical tooling.

PRINCIPLE

The pieces to be welded are held in two clamps as for flash welding. One of the clamps in stationery while the other is mounted in a slide and backed up against a heavy spring. When the movable clamps is released it advances rapidly towards the fixed clamp carrying the work piece.

As the distance between the ends of the work pieces reduces to less than about 1.5 mm, then the stored electric energy causes intense arcing over the surfaces raising the temperature. As the two parts come together the arc is extinguished due to the percussion blow.

The energy required for causing the discharge may be built up either by the electrostatic method using a capacitor or by the electromagnetic method using a collapsing magnetic field linking the primary and secondary windings of an inductive device or transformer. A Protective gas shield around the weld may be provided when welds of very high quality are desired. The process is used in



the butt welding of bars, rods, tubes and pipes. Theses welding machines

are built for automatic operation and have pre-set controlled parameters at each stage of the cycle.

Welding Force:

Welding force may be applied by:

1. Pneumatic,

2. Electromagnetic,

3. Spring force or

4. Gravity (falling weights).

Advantages of Percussion Welding:

1. The action takes place in a very little time, usually less than 0.1 Seconds

2. It causes very little damage to material close to the weld.

3. Hardened surfaces may be welded without any danger of annealing.

4. As the heat is concentrated at the ends of the work pieces heat balance is not much of a problem.

5. Parts with different thermal conductivities or different masses can be easily welded.

Disadvantages of Percussion Welding:

1. The process cannot be used for welding heavy sections larger than 600 mm^2.

2. The process is limited to butt welded joint only

Applications of Percussion Welding:

1. Welding of satellite tips to tools

2. Welding of Steel to Cast Iron

3. Welding of Zinc to Steel

4. Welding of Copper to Aluminium etc.,

5. Welding of Studs

6. Join a stranded wire directly to a component pin on axis